Capacitor Assembly Automation

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Presentation Overview

- Background information
- Project needs and goals
- Assembly steps/breakdown of time for each step
- Prototype designs/challenges
- Future work

Background Information

- Unison Industries
  - Subsidiary of GE
  - Specialize in electrical components for jet engines, ignition systems and generators
  - 80% of jet engines are installed with ignition systems produced by Unison Industries
- Capacitors store energy as an electrostatic field
- Capacitor Assembly Automation
  - Making a manual process automated in order to reduce assembly time
- Options of fully automatic versus semi automatic
  - Fully automatic requires no operator
  - Semi automatic requires some use of the operator

Project Needs

- Need Statement: The project requires an automated system to be developed in order to assemble the capacitors. The capacitors consist of the following parts:
  - 4 individual capacitor sections that become stacked together
  - A layer of tape and insulator paper between each section
  - Electrical tabs for connections
  - Lead wires
  - Insulation material wrapped around the assembly

Figure 1: Individual capacitors

Project Goals

- Goal Statement: Design and develop an automated process in order to improve the manufacturing and assembly of the capacitor

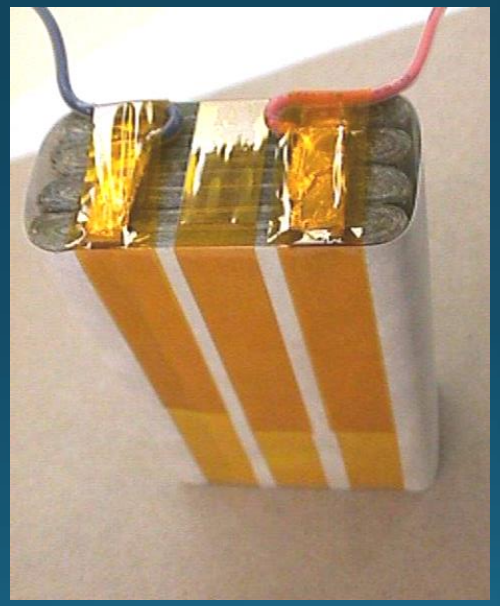

Figure 2: Assembled capacitor: 1.38" x2.6" x 4.25"

Updated Objectives

- Finalize which steps will be automated
- Develop methods to improve steps that will have automation added to them
- Reduce overall assembly time
- Develop working prototype

Product Specs

- 4 individual sections
  - Layer of insulation paper and double sided tape in between
- Electrical tabs soldered together
- Insulation material wrapped around whole thing
- Dimensions: 4.25”H x 2.6”L x 1.38”W

Figure 3: Induvial Capacitor 2.6” x 4.25”

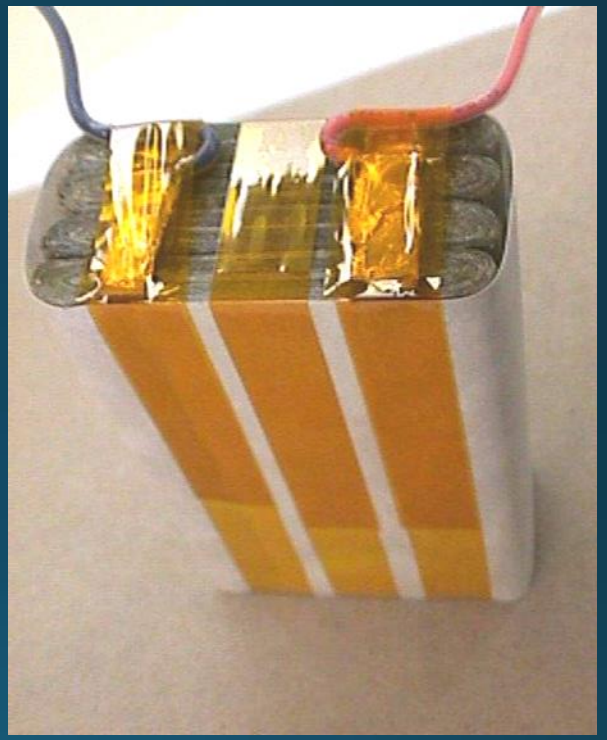

Figure 4: Assembled Capacitor 1.38” x 2.6” x 4.25”

Assembly Steps

1. Select 4 capacitor sections and attach clipped tabs together and verify capacitance is within range. If not select different capacitors to meet capacitance range
2. Cut a piece of tape and place between each capacitor section. The clipped tabs must line up on one side.
3. Form capacitor tabs and solder
4. Attach and solder wire to clipped tabs and wire to unclipped tabs

Assembly Steps Con't

5. Assemble sleeving wires
6. Assemble tape over both soldered tabs
7. Form safety loop in both wires shown
8. Wrap an piece of insulation around sides of pack
9. Secure insulation and wires in place using Tape
10. Final Inspection
    A. Using Verniers, check the following dimensions:
        i. 4.25" max, 1.38" max, 2.60" max
    B. Visually inspect the following:
        i. Correct and complete assembly
        ii. Damage to wires or assembly

Estimated Breakdown of Time

- Placing tape on capacitors: 1 min 43 sec
- Stacking: 31 sec
- Soldering: N/A
- Attaching lead wires: N/A
- Wrapping insulation paper: 2 min
- 3 Pieces of tape around assembled capacitors: 52 secs
- Dimension Check: 1 min 4 sec

Step 1 Design: Tape Roller

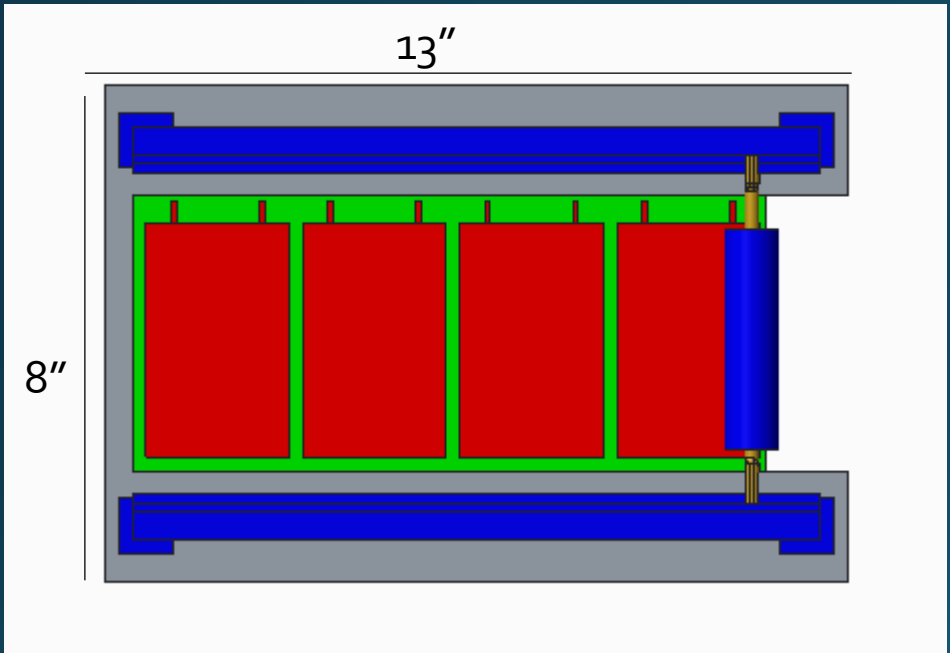

Figure 5: Top view of Tape Roller

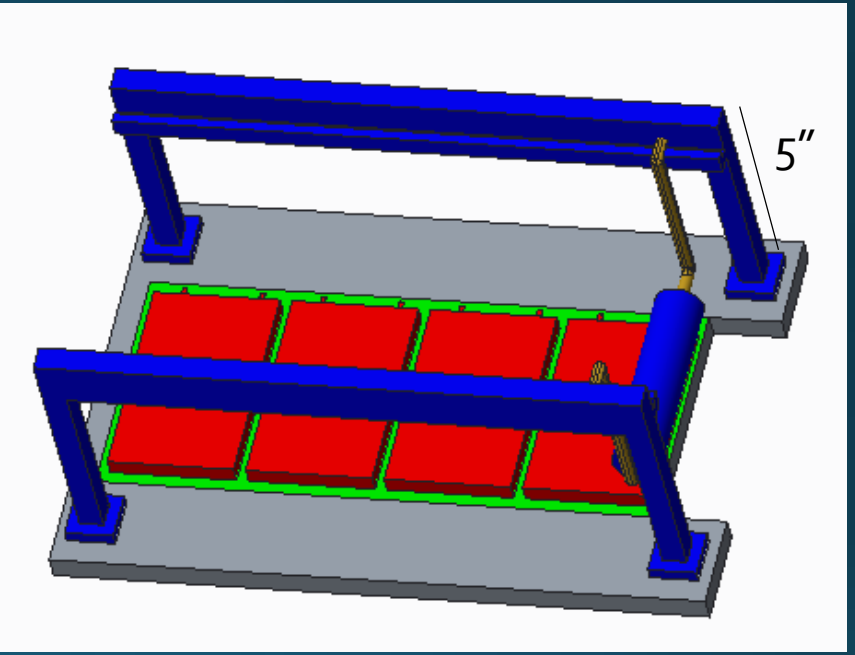

Figure 6: Angled View of Tape Roller

Step 1 Con't

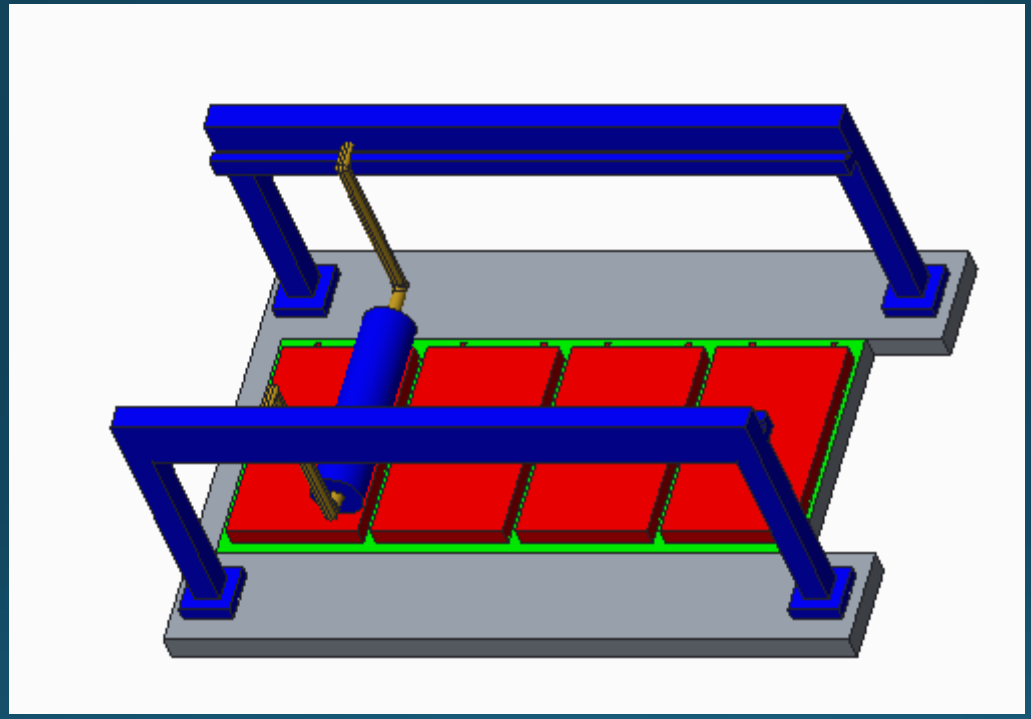

Figure 7: Tape Roller in Process of rolling

Possible Challenges

- Initial placement of the tape
- Tape doesn't properly dispense onto capacitors
- Motor failure
- Track or roller arms could wear out over time

Step 2 Design: Stacking

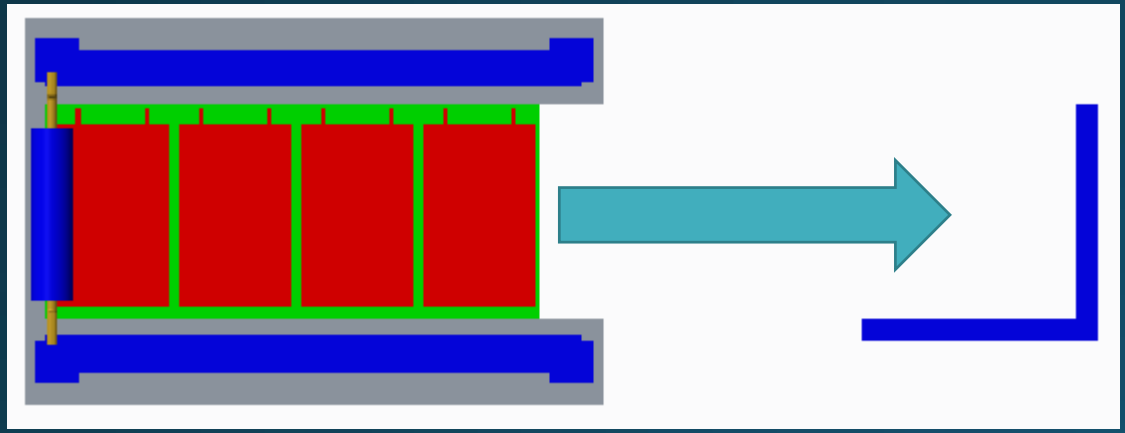

Figure 8: Top view of Tape Roller with L-Gauge

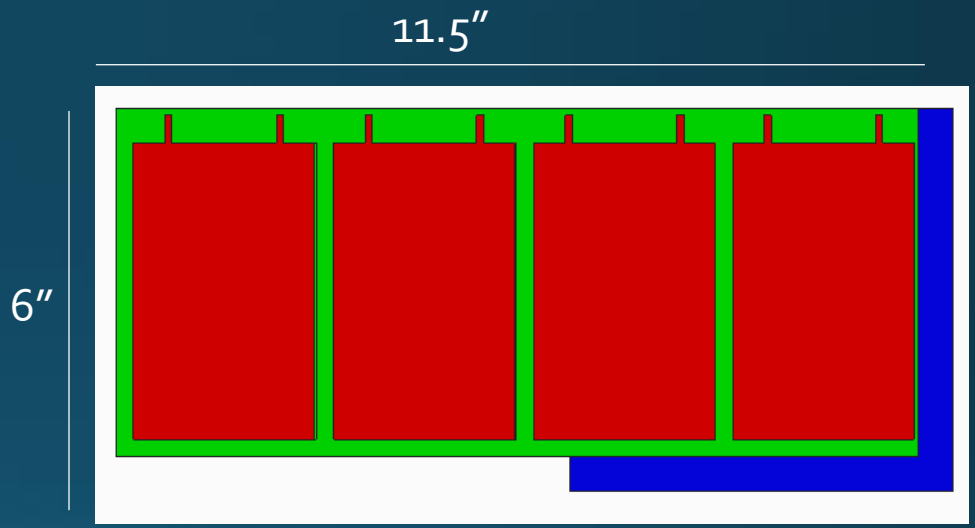

Figure 9: Top View of Plate in L-Gauge

Step 2 Con't

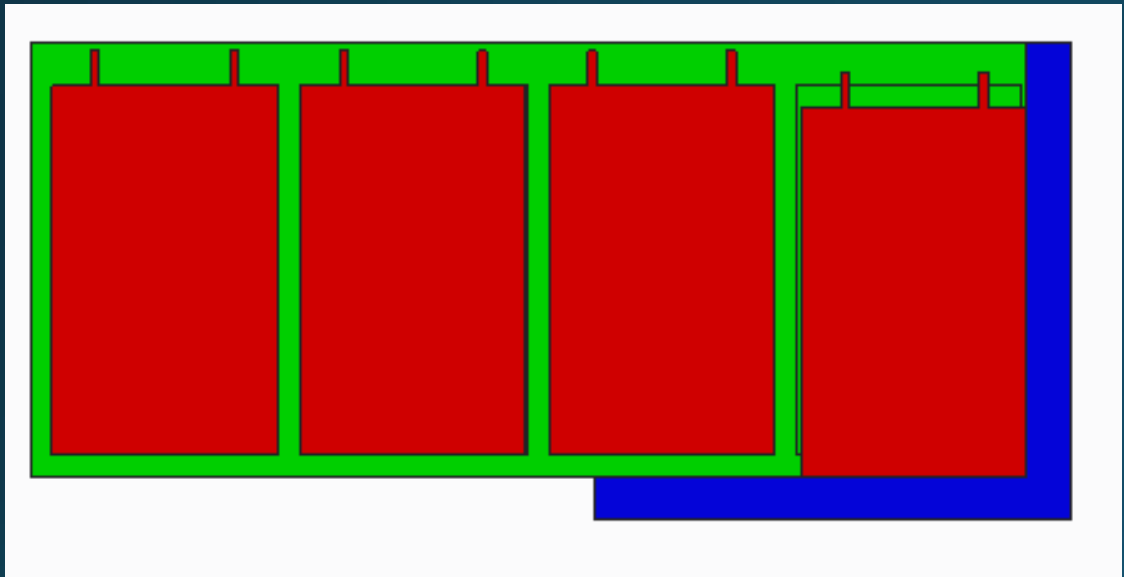

Figure 10: First capacitor section being placed into L-Gauge

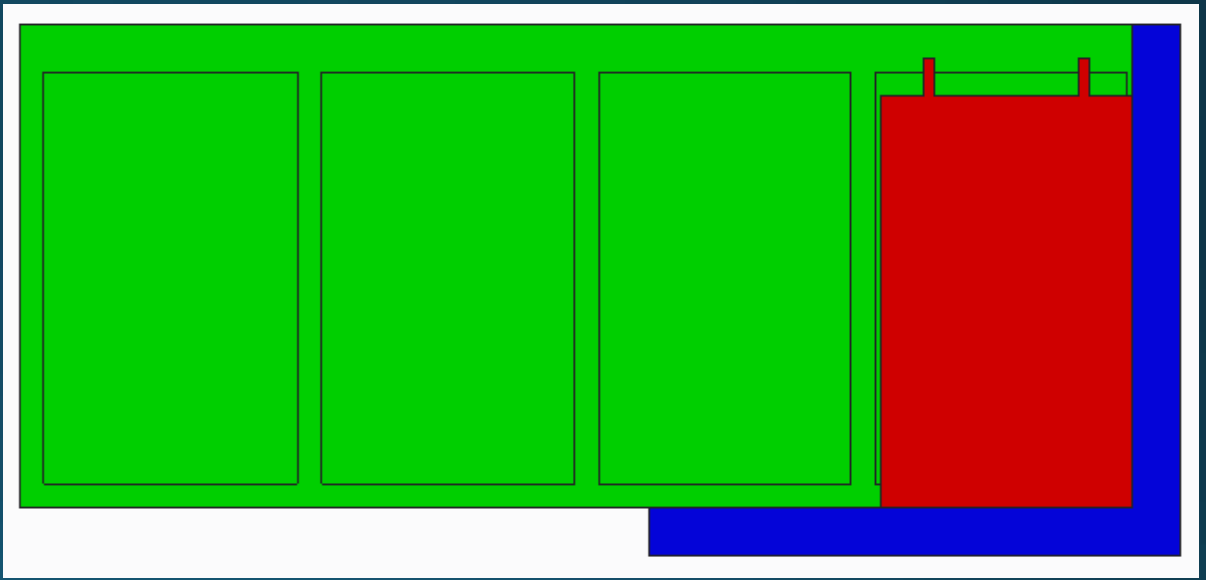

Figure 11: All 4 sections stacked in L-Gauge

Step 2 Con't

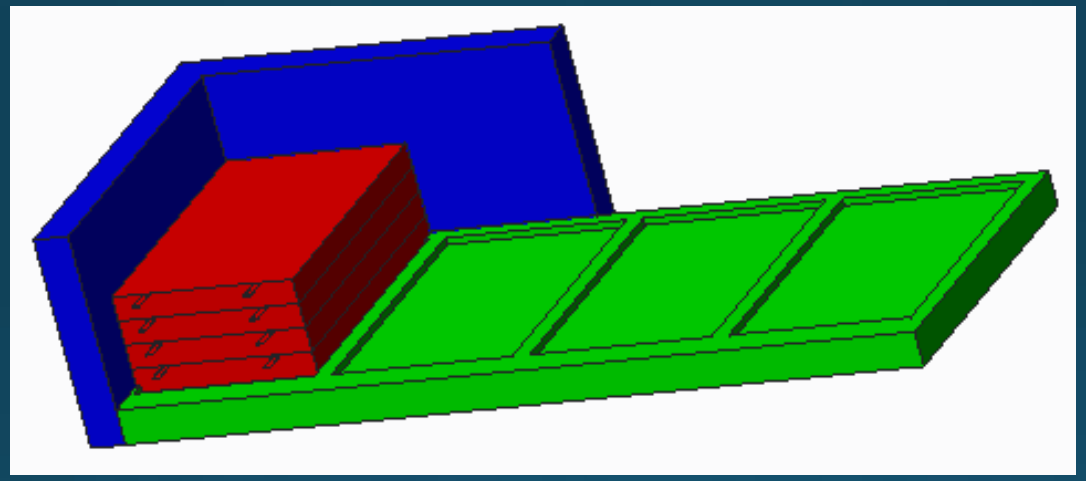

Figure 12: Angled View of Stacked Capacitors

Alternative for Stacking Process

- "Pick and Place" Robot
  - Picks up each part using claw-like mechanism
  - Uses Pneumatic system
  - Computer programed
  - Potential to be used in future work

Figure 13: "Pick and Place" Robot

Possible Challenges

- Manual Process
  - Might not be as quick as a robot
  - The L-Gauge might wear out over time
- "Pick and Place" Robot
  - Programming
  - Robot breaks
  - Parts might slip out of the claw
  - Acquisition cost: $2,000-$8,000

Wrapping Design

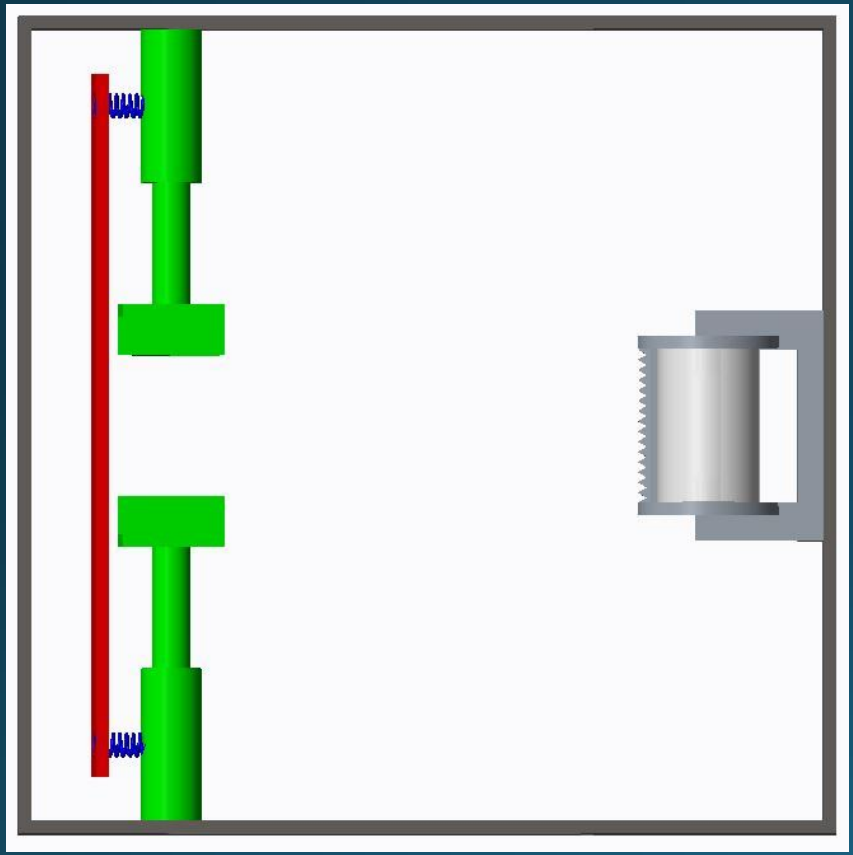

Figure 14: Wrapping machine without capacitor assembly

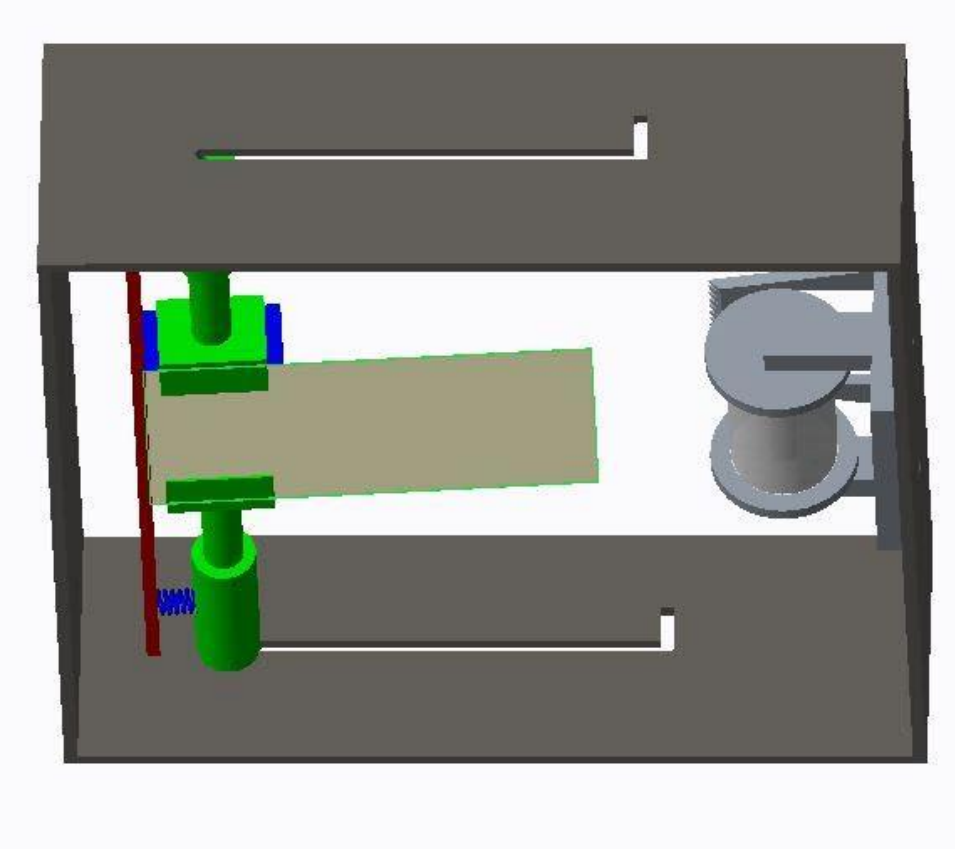

Figure 15: Wrapping machine with capacitor assembly and attached insulation paper

Wrapping Con't

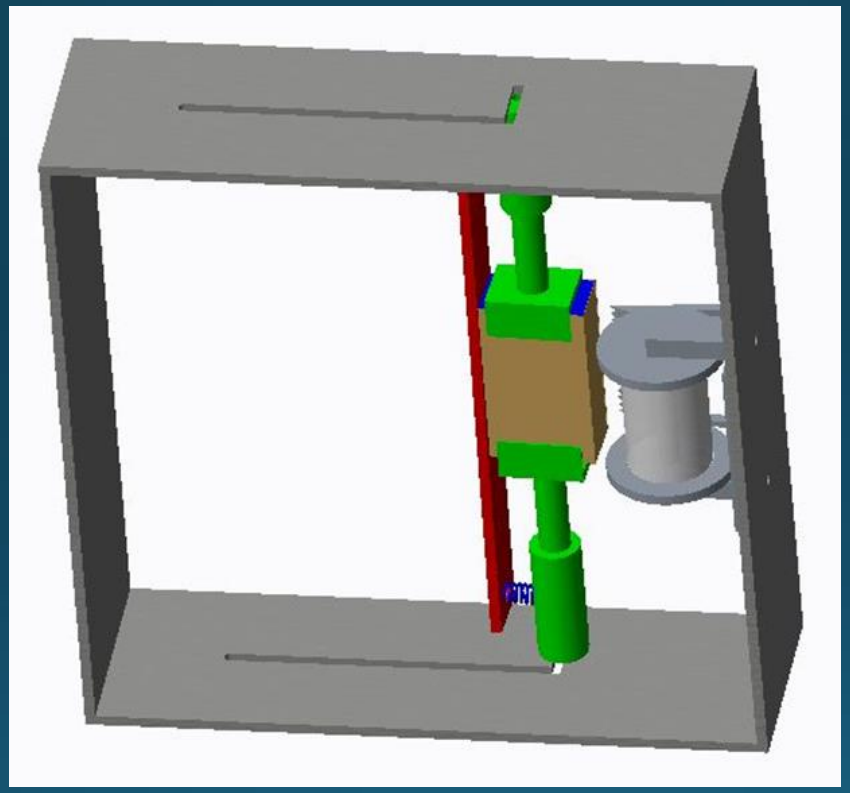

Figure 16: Wrapped capacitor assembly moving backwards to cut tape and finish wrapping process

Possible Challenges

- The assembly has to be loaded with the insulation paper attached with double-sided tape to the front of the assembly
- Currently the tape must be manually attached to the insulation paper before the wrapping is started
- Tape roll needs to be kept at a near constant tension throughout the life of the tape roll so the insulation paper is wrapped tightly
- Needs to be programmed

Steps Not Being Automated

- Soldering of metal tabs
  - Certified process
- Attaching lead wires
- Stacking process
  - Created manual process
- Dimensional Check
  - Created manual process

Dimension Check

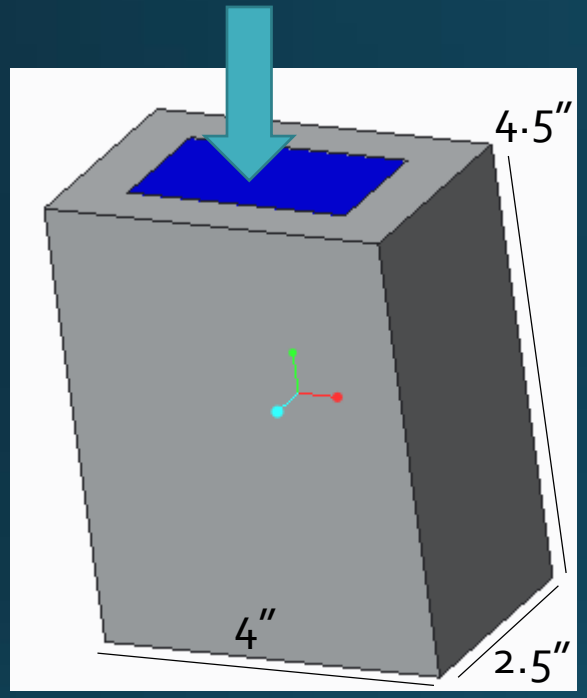

Figure 17: Design 1 for Dimension Check

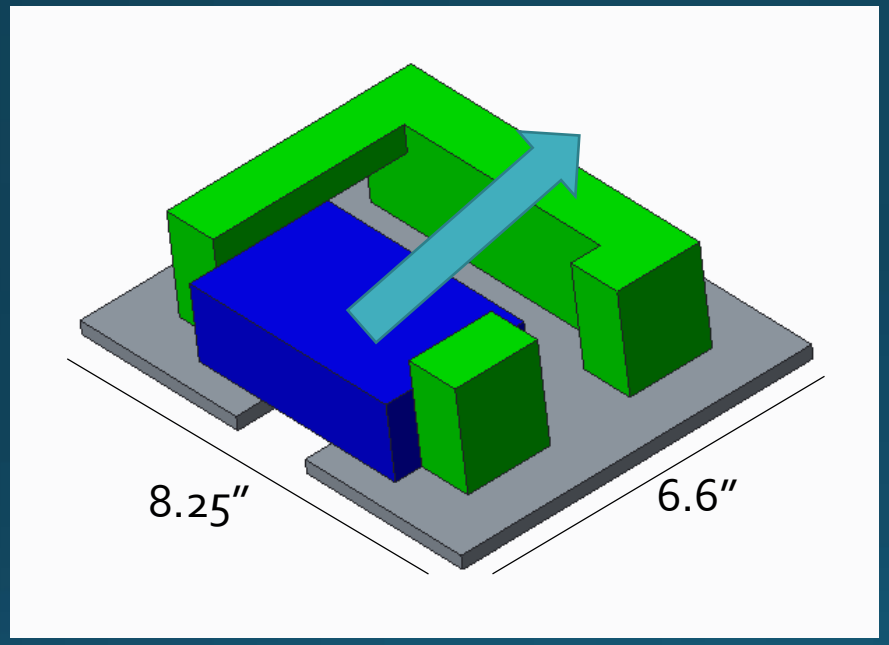

Figure 18: Design 2 for Dimension Check

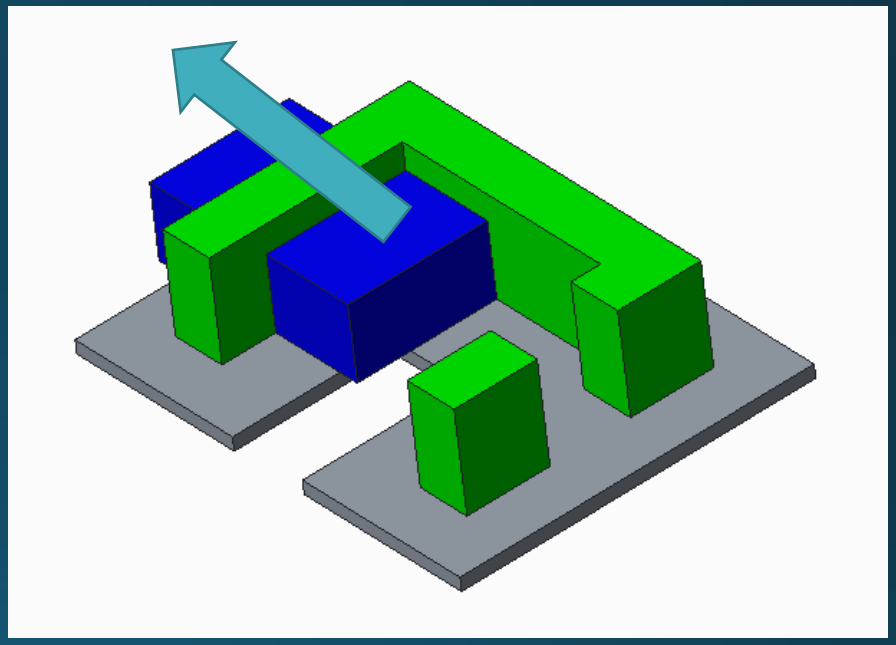

Figure 19: Design 2 for Dimension Check

Decision Matrix

Parameters	Design 1	Design 2
Cost	5	3
Manufacturability	5	3
Efficiency	4	4
Ease of Use	3	4
Total	17	14

Table 1: Decision Matrix for Dimension Check

- Design 1 scored better than Design 2
  - Design 2 is still a potential option if issues arise with Design 1 later on

Gantt Chart

Task Name	Start Date
Planning	**09/13/16**
Schedule Biweekly Meetings	09/13/16
Agree on Scope with Sponsor	09/16/16
Concept Generation	**09/22/16**
Background Research	09/22/16
Conceptual Design	09/22/16
Trip to Unison Industries	10/21/16
Detailed Design	10/21/16
Design Selection	**11/01/16**
CAD Drawings	11/01/16
Risk Analysis	11/15/16
Propose Designs to Sponsor	11/12/16
Pick Final Design	11/29/16
Procurement	**11/30/16**
Bill of Materials	11/30/16
Purchase Orders	12/06/16

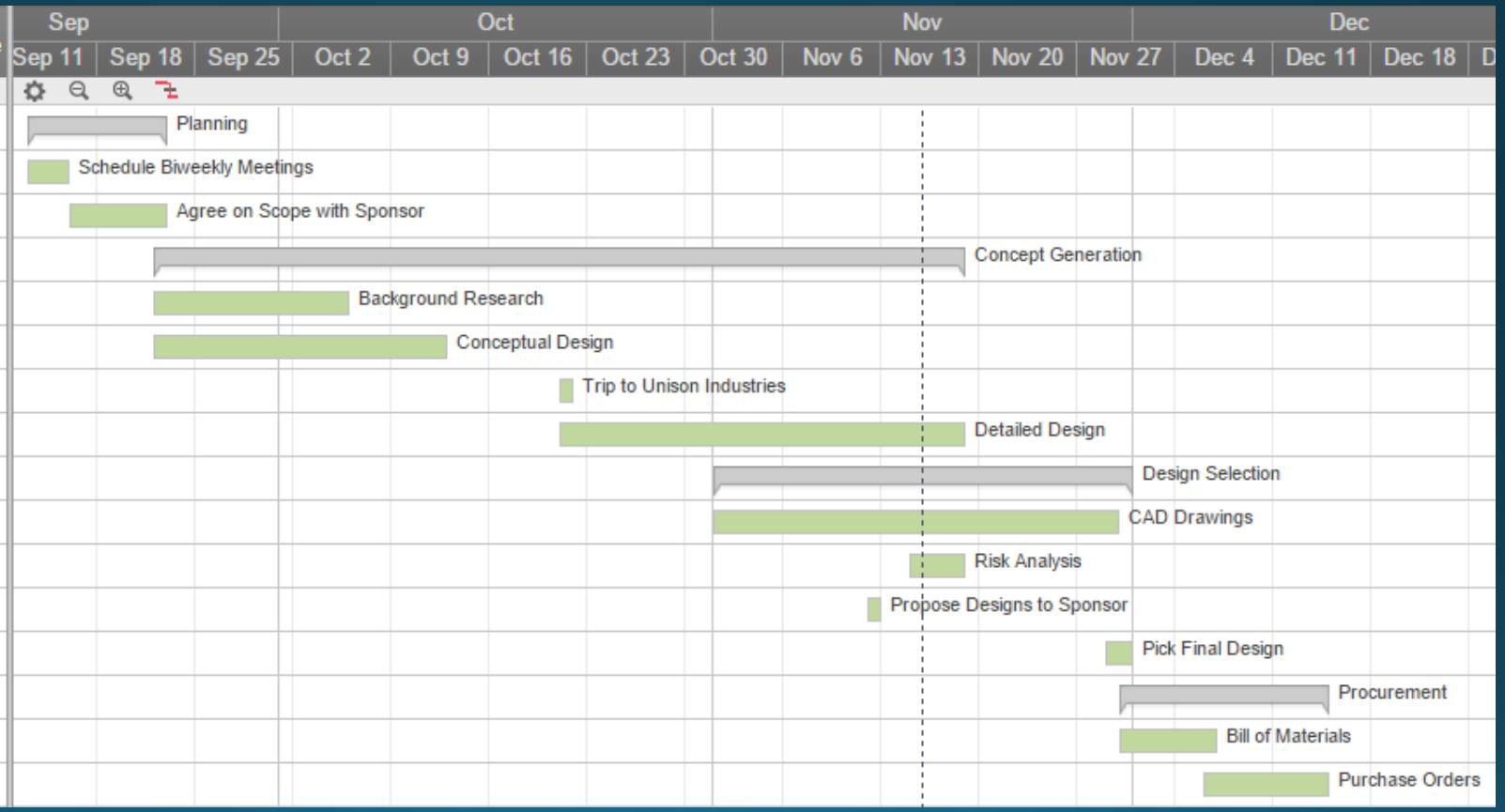

Table 2: Gantt Chart

Future Work

- Create design for wrapping tape on the assembled capacitor
- Explore the option of adding the robot into the stacking step
- Finalize designs and have our sponsor approve them
  - Order material and begin building prototype
- Test the prototype and make any changes as needed

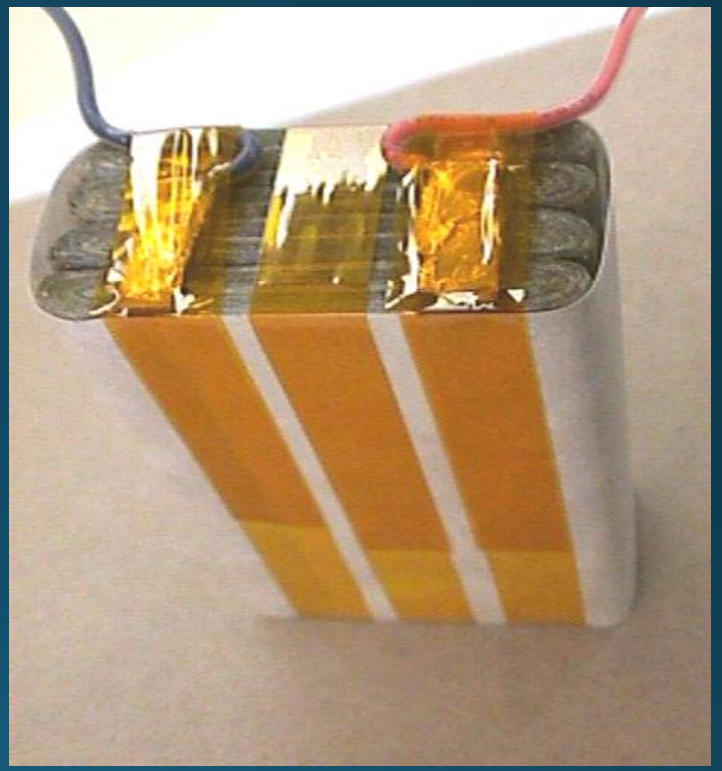

Figure 20: Assembled Capacitor 1.38" x 2.6" x 4.25"

Conclusion

- Created different designs to automate/speed up the following steps:
  - Placing tape on individual capacitors
  - Stacking the capacitors
  - Wrapping insulation paper around the capacitors
- Finalized which dimension check method will be using

References

- Kevin Walker, Assembly Steps Handout
- FANUC AUTHORIZED INTEGRATOR: Robots Workx a Scott Company Retrieved from https://www.robots.com/fanuc/all

Questions?